

Serial No. 10/038,223
Docket No. 17MY-7138

Amendments to the Specification:

Please amend the specification by inserting the "replacement" paragraph(s) set forth below, marked up to show the changes made relative to the immediately prior version of the indicated paragraph(s).¹

Paragraphs [0009], [0017], [0018] and [0020] are replaced with the following replacement paragraphs:

9, [0009] The above alloy differs from the Carpenter Custom 450 stainless steel in several important aspects. First, the focus of the Custom 450 alloy is corrosion resistance, and not a combination of high strength and toughness. To achieve improved toughness as compared to Custom 450, the alloy of this invention relies on a particular combination of chemistry, microstructure and tempering temperature. In terms of chemistry, the alloy employs a very narrow range for carbon content, a range of Nb/C ratios higher than Custom 450 (U.S. Patent No. 3,574,601 ~~3,754,601~~), and a very limited nitrogen content to promote impact toughness. Also preferred to meet the required impact toughness is a grain size of ASTM 5 (average grain diameter of 62 micrometers) or finer, and more preferably a grain size of ASTM 7 (average grain diameter of 32 micrometers) or finer. Also important to the alloy is a delta ferrite content of less than 0.5 weight percent, in view of the negative effects of the delta ferrite phase on mechanical properties. Finally, the processing of the alloy includes an austenizing heat

¹ Strikethroughs indicate deletions and underlining indicates insertions.

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treatment at a temperature of about 980°C to about 1100°C, followed by tempering (aging) at a temperature of about 900°F to 975 °F (about 480°C to about 525°C). The tempering heat treatment is particularly important to obtaining the strength and impact toughness properties required by this invention. Aside from the assumption that the alloy does not contain any prior melt or process related defects, it is believed that the desired mechanical properties of the precipitation-hardened stainless steels of this invention do not rely on prior melting practices, thermal mechanical processing, and heat treatments as long as the chemistry, grain size and tempering range (480°C to about 525°C) conform to that noted above.

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[0017] In view of the above, chromium, nickel, copper, molybdenum, carbon and niobium are required constituents of the stainless steel alloy of this invention, and are present in amounts that ensure an essentially martensitic microstructure. As in the Custom 450 alloy (U.S. Patent No. 3,574,601 ~~3,754,601~~), copper is critical for forming the copper-rich precipitates required to strengthen the alloy. Notably, the invention employs a very narrow range for carbon content, a range of Nb/C ratios higher than Custom 450, and a very limited nitrogen content to promote impact toughness. More particularly, nitrogen contents above 0.03 weight percent were determined to have an unacceptable adverse effect on toughness.

[0018] Carbon is an intentional constituent of the alloy of this invention as a key element in the formation of complex and simple carbides that act as an additional strengthening mechanism with the copper-rich precipitates. However, in comparison to other steels such as Type 422 (carbon content of about 0.10 to 0.20 weight percent), carbon is maintained at impurity-type

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levels. The limited amount of carbon present in the alloy is stabilized with niobium so as not to form austenite. The relatively high Nb/C ratio is contrary to U.S. Patent No. 3,574,601 ~~3,754,601~~ (Custom 450), but in accordance with this invention is necessary to achieve the desired level of impact toughness. In the past, niobium levels were kept very low on the basis of a theoretical ratio of about 8:1 required to completely tie up all niobium and carbon. What role any excess niobium might play in the strength or toughness of a precipitation-hardened stainless steel was not established. However, with this invention, it is believed that higher niobium contents (relative to carbon) impact carbide formation of the other major carbides present in the alloy (e.g., chromium carbides, molybdenum carbides, etc.), and may also influence the precipitation reaction during tempering. At the minimum Nb/C ratio of 10, maximum toughness is achieved when using a minimum amount of strengthening agents to obtain a desirable strength level. At the preferred maximum Nb/C ratio of 15, acceptable toughness is still achieved for a maximum amount of strengthening agent. At Nb/C ratios of 15 to the maximum of 20, toughness is lower but still acceptable for many applications.

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[0020] As known in the art, chromium provides the stainless properties for the alloy, and for this reason a minimum chromium content of 14 weight percent is required for the alloy. However, as discussed in U.S. Patent No. 3,574,601 ~~3,754,601~~, chromium is a ferrite former, and is therefore limited to an amount of about 16 weight percent in the alloy. The chromium content of the alloy must also be taken into consideration with the nickel content to ensure that the alloy is essentially martensitic. As discussed in U.S. Patent No. 3,574,601 ~~3,754,601~~, nickel promotes corrosion resistance

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and works to balance the martensitic microstructure, but also is an austenite former. The narrow range of 6.0 to 7.0 weight percent nickel serves to obtain the desirable effects of nickel and avoid austenite. Molybdenum also promotes the corrosion resistance of the alloy, while also being effective to avoid hydrogen embrittlement. The relatively narrow range for molybdenum specified for this alloy has the effect of reducing the amount of delta ferrite, which is required to be kept to particularly low levels in the alloy as will be discussed below. It may be possible to substitute tungsten for all or part of the molybdenum content of the alloy.

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